DOCUMENT RESUME

ED 252 400 SE 045 319

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TITLE Children's Questions and Science Teaching: An Alternative Approach. [and] Floating and Sinking: Some Teaching Suggestions. Learning in Science Project (Primary). Working Paper No. 117 [February 1984 and November 1983 Versions].
INSTITUTION Waikato Univ., Hamilton (New Zealand). Science Education Research Unit.
PUB DATE Feb 84
NOTE 33p.; For related document, see SE 045 303.
PUB TYPE Reports - Evaluative/Feasibility (142) -- Guides - Classroom Use - Guides (For Teachers) (052)

EDRS PRICE MF01/PC02 Plus Postage.
DESCRIPTORS Concept Teaching; *Curriculum Development; Elementary Education; *Elementary School Science; Foreign Countries; Learning Strategies; *Physics; Questioning Techniques; Science Curriculum; Science Education; *Science Instruction; Science Projects; Scientific Concepts; *Teaching Methods
IDENTIFIERS *Learning in Science Project (Primary); *New Zealand; Questions; Science Education Research

ABSTRACT

Two booklets were developed by the Learning in Science Project (Primary)--LISP(P)--to help teachers adopt an approach to primary science teaching which would enhance children's understanding of floating and sinking. Both booklets were designed to enable teachers to reconceptualize their teaching task from activity-driven, didactic teaching to conceptual-change teaching. The first booklet (dated November 1983) was written for teachers preparing detailed guidance. The second booklet (dated February 1984) was written for more confident teachers, using a less structured approach. The earlier version emphasizes floating and sinking and contains: (1) information about the ideas that children hold on this topic; (2) information about the ideas that scientists hold on the topic; and (3) suggested investigations, experimental projects, and non-experimental projects to help children move gradually from intuitive explanations toward those which will ultimately be more useful to them. The investigations are designed to examine which materials float, if holes in floating materials affect their floating, if the depth of water affects floating, and if the length of an object affects its floating. The experimental projects are designed to examine how non-floating materials can be made to float, how a sunken object can be raised, which material is the best floater, and the amount of water displaced by the same object while floating or sinking. The non-experimental projects are used to examine practical applications of floating and sinking. Each investigation or project includes suggested procedures and statements of both children's and scientists' views of the particular phenomenon under consideration. The later booklet emphasizes a general approach to science teaching and contains a five-step approach that helps students to: acquire scientific understanding and knowledge for themselves at their level; ask genuine questions; seek more information; test out their present ideas; construct reasoned explanations; and develop scientific attitudes. The instructional tasks involved in the five steps include: (1) eliciting and recording children's questions: (2) helping children decide which questions should be investigated; (3) assisting them in planning their investigations; (4) providing assistance during their investigations; and (5) helping them record and report their findings. A set of teacher's notes on "floating and sinking" is provided in an appendix. These notes include information on scientists' and children's explanations of floating and sinking, a list of questions children aged 9-12 most often ask about the topic, and suggestions for initiating activities to focus children's questions about various aspects of floating and sinking. (JN)

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LEARNING IN SCIENCE PROJECT
(PRIMARY)

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CHILDREN'S QUESTIONS AND SCIENCE TEACHING: AN ALTERNATIVE APPROACH

Suggestions for teachers who feel comfortable about class control, with an appendix containing notes about 'Floating and Sinking'

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February 1984

Working Paper No. 117

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PURPOSE OF THIS BOOKLET

The purpose of this booklet is to outline an approach to science teaching that involves helping children with investigations based on their questions about a particular topic.

SPECIAL NOTE: It is not suggested that this is the way to teach science; it is simply one alternative. Indeed if you feel less adventurous then you may wish to to try our other booklet first (Working Paper No.117) and perhaps attempt this approach at a later time.

PERSPECTIVE UNDERLYING THE APPROACH

The approach is based on the major aim of primary science education in New Zealand, namely

> "Developing an inquiring mind and the skills for exploring and interpreting the environment."
>
> (Infant - S4 Syllabus & Guide, p.4)

Children's questions are central to the inquiry process. Furthermore experience has shown that their questions about a topic

(i) provide an indication of the ideas - both sensible and misleading - or lack of ideas that they have of it, and

(ii) can generate considerable interest among themselves in the topic and lead to highly meaningful investigations of it.

The approach also recognises that:

(iii) the point of developing skills is to enable children to gain understanding;

(iv) when children really want to make sense of something it provides them with a powerful incentive to improve their processing skills;

(v) each child has to construct meanings for him or herself;

(vi) the meanings which children generate result from an interaction of the ideas they bring to the setting, the phenomena they encounter there, and the skills (mostly intellectual) they use to process them;

(vii) children should occasionally have the opportunity to learn from their own mistakes.

THE TEACHING TASK

In general terms the task of the teacher is seen as providing children with opportunities and assistance to inquire about and investigate things and ideas which are meaningful to them so that they can make better sense of their natural and technological world. More specifically, it involves helping them in the following ways:

1. Knowledge - assisting them acquire scientific understandings and knowledge for themselves at their level;

2. Skills
   (a) encouraging them to ask genuine questions about things they observe or ideas they come across;
   (b) encouraging them to seek more information about particular events or phenomena;
   (c) helping them to test out their present ideas and questions against available evidence;
   (d) guiding them to construct reasoned explanations consistent with the evidence and logic;

3. Attitude - assisting them to appreciate that there is a tentativeness about all scientific explanations and that knowledge claims, if they are to be called scientific, must be capable of being tested.

NOTE: This approach is different from the traditional one that many of us have used previously. That approach involved trying to transmit to children knowledge which we thought was suitable for them. In so doing we tended to stifle their own inquiry, as some teachers have recognised.

> "I think it's the way you teach things [it] could even perhaps squash an inquiring mind."
>
> (J3-S2 teacher)

> "I think that as a race we [teachers] do inhibit kids asking questions because we talk too much ourselves."
>
> (Primary principal)

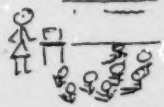
SUGGESTED TEACHING APPROACH

This is based on 'Developing Interests and Attitudes'
(NZ Infant - S4 Science Syllabus and Guide, Section 4)

The approach in outline

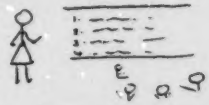
STEP 1
Provide your children with experiences that will enable them to ask questions. Record their questions.

PROVISION OF INITIATING ACTIVITIES



STEP 2
Decide which questions are to be investigated.

DECISION RE QUESTIONS

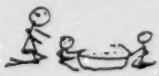


STEP 3
Assist the children to plan their investigations.

GUIDANCE WITH PLANNING

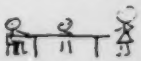
STEP 4
Provide assistance to the children during their investigations.

ASSISTANCE WITH INVESTIGATIONS



STEP 5
Assist the children to record, interpret and report their findings.

HELP WITH FINDINGS



The approach in more detail

1. Eliciting and recording your children's questions - perhaps one lesson

With some topics children can probably draw on past experiences and knowledge to formulate questions, so that perhaps the only stimulus required is a picture or example of the thing to be studied. With other topics, however, the children may not know enough about them to have a basis on which to ask questions. In these cases more extensive initiating activities will be required. Possible activities include

* demonstrating something to the children (a discrepant event - one that you know is at odds with the ideas children usually have - is one possibility),
* showing them a film, filmstrip, slides,
* presenting them with instances (and non-instances) of some phenomenon or event and encouraging them to offer their views about these,
* reading them an article,
* letting them explore some apparatus or materials,
* letting them observe at some site.

The suggestions made in this section so far could result in children asking an extremely wide range of questions about a topic. This is not necessarily a bad thing; quite valuable learning could take place. You may feel, however, that since we seldom have unlimited time in the classroom for such studies that you would be happier if the children pursued questions related to ideas about the topic that seemed important to their further understanding of it at higher levels. To some extent it does seem possible to focus children's questions in such a direction by providing initiating activities that draw their attention to particular aspects of the topic. The activities already suggested can be used in this way.

You may find at first that the children cannot think of many questions. However, if they begin asking them publicly in a whole class group and you record them either on the board or on a chart one by one then it is likely to stimulate considerable

interest in the topic by other children in the class and they will ask questions which then occur to them. Some teachers have found that after a while it is not a matter of eliciting questions but deciding when to stop them as the children keep on asking. (This problem may not be so great with later topics as the children learn to differentiate between questions which are investigable and questions which are not.)

There may be times, with older children especially, when you would like them to write their questions on paper either individually or working in mini-groups (up to 3 children).

NOTES:

* We are only interested in children asking genuine questions, that is, questions that they don't know the answers to already.
* One difficulty that a number of teachers have said they have had to overcome in obtaining children's questions is a strong urge to teach the children immediately a question is asked, especially if the question reveals that the child has a misleading idea.
* When you first attempt this approach you may find it convenient to end the lesson when the children's questions have been recorded so that you can think about the next step.

2. Deciding which question(s) may be investigated - this may take up to one lesson, depending on the means used

Children usually generate such a range of questions that some means has to be used to select one or more for study. Possible means of selection are:

(i) let individual children or mini-groups choose a question that particularly interests them;

(ii) let the children group the questions in a way that makes sense to them and allow them (either individually or in mini-groups) to choose a group of questions that interests them;

(iii) classify the questions into those which are

* investigable by the children via practical activities,
* investigable by the children via consultation of people or books,
* investigable, but are beyond the topic,
* investigable, but would be too difficult for the children,
* not investigable using scientific methods,

and choose, or allow the children to choose, one or more from the first two categories;

(iv) select a question which seems a very basic one, that is, it could lead to ideas which are important to children's further understanding of the topic. Such a question will frequently encompass a number of others asked.

NOTES:

* You may be able to think of other useful ways of deciding which question(s) should be the focus of study.
* Sometimes it is possible to rephrase some of the children's questions so that they are more amenable to investigation but are still meaningful to the children.
* It is not always clear what children mean by some of their questions and it may be necessary to have them clarify them. Sometimes this can be done by having them suggest a possible answer.

3. Assisting children to plan their investigations - this may take one lesson or so

The children's investigations may be both practical and consultative (that is, consulting people and/or books). With both forms, however, the children will probably need considerable guidance in planning their investigations so that they will be able to, for example,

(i) use appropriate materials/apparatus,

(ii) carry out fair tests,

(iii) consult suitable people or books,

(iv) visit worthwhile sites,

(v) collect relevant and sufficient data,

(vi) have a realistic time-frame,

(vii) exercise concern for people and environment.

You may find that a 'science plan' or 'science investigation guide' (or whatever you like to call it) would provide a useful framework for children planning their investigations. At the S2-4 level they could perhaps make a written plan under headingssuch as:

1. NAME(S)
2. TOPIC
3. OUR QUESTION(S)
4. OUR INVESTIGATION
   (a) What we want to ask someone:
   (b) Who we could ask:
   (c) What we want to read about:
   (d) What we think we could do:

NOTE: It will become obvious from the children's plans just what materials are likely to be needed. Some teachers have found that the approach can be fairly demanding in terms of the materials required by the children for their investigations and that it is therefore advisable to have suitable reference material (if any is available) on hand before the study begins so that during the study attention can be given to collecting the practical materials required.

4. Provide assistance to the children during their investigations - the investigations may take one or several lessons

The children will be developing their skills at the same time as they will be developing their ideas, and they are likely to need considerable help with both. The help may include

(i) sympathetic challenging of their present ideas,

(ii) drawing their attention to aspects that they may be overlooking,

(iii) suggesting alternative methods, materials or other resources, if necessary,

(iv) acting as a resource person if you happen to have information that they request.

5. Helping children record and report their findings - this may take one or more lessons

The children will probably need guidance in, for example,

(i) what to record (e.g. repeated measures rather than a single measure),

(ii) how to record it (e.g. chart, table, graph, sentence),

(iii) what meaning can or cannot be taken from the data, and how this connects with what they already know; here the children may be encouraged to make use of analogy ("Oh, I see, that's a bit like ..."), or to recall images, episodes or ideas from past experiences that may be related to their present investigation,

(iv) reporting the investigation and its results (e.g. booklet, chart, model, drawing, tape).

NOTE: At the primary level, children tend not to be so interested in investigations relating to questions other than those they have been pursuing themselves so that having a group of children talk to the rest of the class about an investigation that they alone conducted would not necessarily go very well. Some teachers have found that having short reporting-back sessions by the children after steps 2, 3, 4 and 5 is better.

POSSIBLE VARIATIONS TO THE TEACHING APPROACH

1. Children could suggest likely explanations

A possible variation to the teaching sequence is to have the children themselves propose possible explanations to the questions they are about to investigate. After they have completed their investigations they could compare their conclusions with their proposed explanation.

2. Some questions may be simply explained

Some of the children's questions can be simply explained. At the end of the study you may wish to return to some of the unanswered questions that you know about and offer a simple explanation. We have found that children are usually still interested in their unaswered questions and appreciate explanations.

FINAL CONSIDERATIONS

1. The scientific method

There used to be (maybe still is) much talk about scientific method. However, scientists would say that when they are investigating they use their common sense and whatever method seems best to solve the problem at hand. We suggest that primary science education be approached in the same way, that we simply use our common sense to guide children in their investigations. For example, if we want to find out whether a system of pulleys makes it easier to lift a certain load then it is common sense to get a measure of the load without using the pulleys so that we have a basis of comparison. Children, even able 10 and 11 year olds, don't necessarily think to do this.

We would also add that it is not really necessary to know all the answers to children's questions - some questions will turn out to be impossible to answer anyway - but it is important to join with the children in their search for answers or their search to find out whether or not their suggested explanations are sensible ones. In the process you will probably find that you learn many fascinating things yourself.

2. Will you survive?

The approach is not without its difficulties. For example, you may find that

(i) sufficient resources (suitable books, equipment, knowledgeable people, etc.) are either not available or you haven't had time to locate them, and

(ii) children pursuing questions in different directions is something which is not easy to manage.

Do not feel guilty about postponing (or even cancelling) the lessons if you get into difficulty the first time. You will probably have learnt much about yourself and your children, and if you take up the challenge again later then you may find that you can handle the children's questions more easily or anticipate more accurately what resources are likely to be required.

APPENDIX

FLOATING & SINKING

SCIENTISTS' AND CHILDREN'S EXPLANATIONS ON FLOATING AND SINKING

To assist children make better sense of their world it is helpful to know what ideas they already hold. We have found that they hold a range of ideas about floating and sinking, including in some cases the scientists' view. You may well find that your own pupils hold some of these.

1. WHAT DOES 'FLOATING' MEAN?

The view of scientists (and some children)

An object is considered to be floating it it is

(i) on top of the water, held there by the surface tension (e.g. a water spider),

(ii) at the surface and partly immersed (e.g. a ship),

(iii) fully submerged but freely suspended in the water (e.g. a fish).

Some children's views

An object is considered to be floating it it is at the surface, partly submerged and stationary.

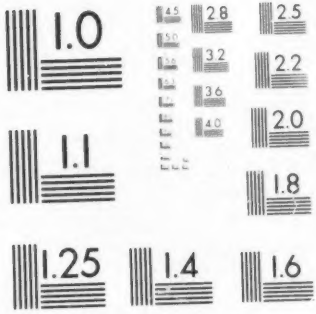
An object may be considered to be partly floating if it has a little bit above water and a substantial amount under water (e.g. an iceberg).

2. WHY DO THING FLOAT?

The view of scientists (and some children)

(i) In simple terms, they float because they are light for their size.

(ii) More technically, things that float do so because they push aside (displace) an amount of water equal to their own weight. For example, a fresh egg pushes aside a certain amount of water but this is not quite equal to its own weight so it sinks. When it goes bad, however,



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
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(ANSI and ISO TEST CHART No. 2)

gases escape through the shell (i.e. it becomes lighter for its size), the amount of water it now displaces is equal to its own weight so it floats.
(Note that this explanation is too difficult for almost all primary children to understand.)

Some children's views

(i) They are light.
(ii) They have air in.
(iii) It's the material they're made of.
(iv) They're water resistant.

3. DOES THE LENGTH OF MATERIAL AFFECT FLOTATION?

The view of scientists (and some children)

If a material floats, then a longer or shorter piece of the same material will float at the same level (e.g. a full length candle will float at the same level as a shorter piece with the same dimensions).

Some children's views

(i) A longer piece will sink because it is heavier.
(ii) A longer piece will float lower because it is heavier.
(iii) A longer piece will float higher because there is more of it being held up by the water.

4. DOES THE DEPTH OF WATER AFFECT FLOTATION?

The view of scientists (and some children)

(i) The depth of water underneath a floating object will not affect the level at which it floats.

(ii) The depth of water on top of floating material will not prevent it floating (e.g. a block of wood placed in very deep water will float up again).

Some children's views

(i) A floating object will float lower in deeper water as it is sort of sucked down a bit.

(ii) It will float higher because there is more pressure of water under it.

(iii) Floating material placed in very deep water will stay down because of the pressure of water on it.

5. WHAT EFFECT DOES REMOVING THAT PART OF FLOATING MATERIAL ABOVE WATER HAVE ON THE MATERIAL'S FLOTATION?

The view of scientists (and some children)

Removing that part of floating material which is above water will result in the material rising to have the same proportion above water. For example, if a floating block of wood was half out of the water, then removing the top would cause the wood to rise so that once again half would be floating above water.

Some children's views

Removing the top part of floating material (e.g. of an iceberg) will cause the part below water level to

(i) sink,

(ii) stay just at water level,

(iii) roll over.

WHAT CHILDREN WANT TO KNOW ABOUT FLOATING AND SINKING

We have found that children aged 9-12 years most often ask questions about:

1. Materials (e.g. Why do most metals sink?)
2. Objects (e.g. How do boats stay up in the water?)
3. People (e.g. When I'm on my back in the pool I'm kind of relaxed and I float but when I twist or turn or lower my legs a bit I go under. Why is that?)
4. Other animals (e.g. How come insects float?)
5. Weight or size (e.g. Why do big ships float and why do little things like paper clips sink?)
6. A general rule (e.g. Why do some things float and some things sink?)

SUGGESTIONS FOR INITIATING-ACTIVITIES TO FOCUS CHILDREN'S QUESTIONS

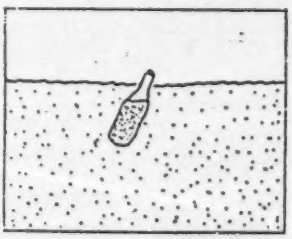
* If you want to focus on the meaning of 'floating' then you may show the children some foil on top of the water, a ball of plasticine under the water, a table-tennis ball suspended in the water by some cotton tied to a weight on the bottom, a golf ball suspended in the water by some cotton tied to a stick at the top, and an apple immersed in the water at the surface. Examples of cards (OHP drawings) that could be used for the same purpose are shown below and on p.14.

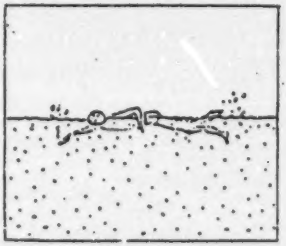
* If you wish to focus on floating and non-floating materials then you may demonstrate that some materials float (e.g. a plastic lid, large piece of wood, pumice) while some sink (e.g. rubber, small piece of chalk).

* If you would like to focus on the fact that some materials can be shaped to float then you may demonstrate that a paper clip sinks while a large ship floats, that a glass jar put in sideways sinks but put in vertically (with some ballast) floats.

* Similarly, other demonstrations using drawings or objects could focus on length of material, depth of water, and so on.

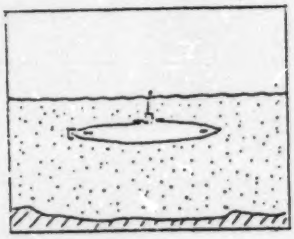
EXAMPLES OF DRAWINGS, PICTURES OR OBJECTS THAT COULD BE USED TO PROVIDE INITIAL EXPERIENCES

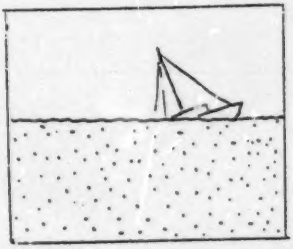


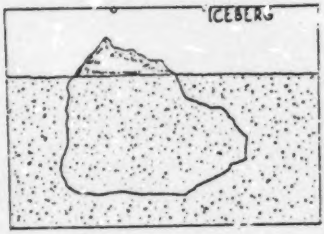


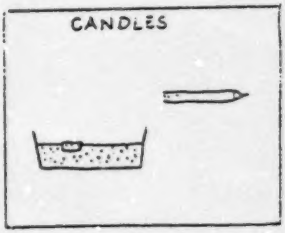
With these, and the next two cards, you could say to the children:

"In the way you think about floating, would you say the ... is floating? Why do you say that?"







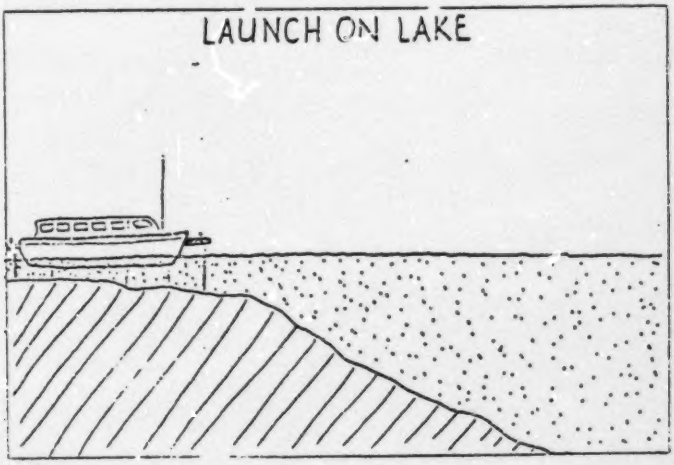


"If we cut the top part off the iceberg, what do you think would happen to the bottom part under the water?"

"Why do you think that?"

"If we put the big candle into the water will it sink, float lower, the same or higher than the little candle?"

"Why do you think that?"



"When the launch goes over into the deeper water will it float lower down, the same level or higher up?"

"Why do you say that?"

LEARNING IN SCIENCE PROJECT (PRIMARY)

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FLOATING AND SINKING

Some teaching suggestions

(Revised version)

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Roger Osborne

Science Education Research Unit
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Hamilton, N.Z.

November 1983

Working Paper No.117

PURPOSE OF THIS BOOKLET

This booklet is designed for teachers who may appreciate some extra guidance in helping children develop their ideas about floating and sinking. The booklet contains

(i) information about the ideas that we have found children hold on this topic,

(ii) information about the ideas that scientists hold on the topic,

(iii) suggested procedures to help move children gradually from intuitive explanations towards those which will ultimately be more useful to them.

We wish to stress that the procedures, investigations and projects outlined in the booklet are suggestions, nothing more. Use any that seem manageable. Try them in a different order if it seems more appropriate to do so. They may suggest to you other aspects that you would like to explore with your children. Feel free to do so. Indeed if you feel a little more adventurous then you might like to consider an alternative approach based on children's questions which we have set out in another booklet (Working Paper No.119).

BASIS OF THE SUGGESTED APPROACH

The approach and teaching suggestions have been developed out of our work with the Learning in Science Project. We were aware of the following things:

(i) Children frequently bring to science lessons ideas which they have already formed from their everyday experiences.

(ii) Some of these ideas may be rather misleading.

(iii) It takes time and a variety of experiences to change children's misleading ideas towards a more scientific viewpoint. In this respect it is important that children's learning experiences be authentic. That is to say, there should be no hidden agenda which could convey the message to the children that they must reach the conclusion required by the teacher, rather than one based on their own observations and thinking. Such a hidden agenda tends to result in children learning (and readily repeating) their teacher's verbal explanation without changing their previous ideas. If they

are to make better sense of their world then they must have time to think through their new experiences.

(iv) Scientists' ideas are generally quite abstract, but they are usually built from a number of less complex ideas which primary children can begin to understand.

(v) To help children begin to understand these less complex ideas it is necessary to know what are their existing ideas.

(vi) Children's development of understanding is bound up with their development of intellectual skills and attitudes. It is the making of better sense of the world that gives purpose to the development of intellectual skills. At the primary level we feel that adult common sense is sufficient to guide children in developing their intellectual skills and understandings in the course of investigations.

SCIENTISTS' AND CHILDREN'S VIEWS ON FLOATING

The purpose of this section is to outline

(i) what scientists mean by the term 'floating',

(ii) what children understand by it,

(iii) what ideas children hold about floating and sinking,

(iv) what children want to know about this topic,

(v) the most useful idea that primary children could develop.

Knowing these things may be useful in helping children with the suggested investigations and projects which follow.

Scientists' meaning of 'floating'

Floating is a complex phenomenon. There are at least 3 types of floating.

1. Floating on a liquid
   - partly submerged, e.g. iceberg

2. Floating within a liquid
   - wholly submerged, e.g. fish

3. Floating <u>on top of</u> a liquid
   - wholly supported by the surface tension, e.g. water spider

Our focus here will be on floating <u>on</u> a liquid.

<u>Children's understanding of the term 'floating'</u>

We have also found that children not infrequently use the term 'floating' in a different way from adults in general and scientists in particular. For instance they may consider that:

1. An object which is more than half submerged is not really floating (it is sinking, or partly-sinking and partly-floating).
2. Only stationary objects are floating (compare with swimming).

It is important for children to realise that the <u>science meaning</u> of floating includes both moving and nearly submerged objects.

<u>What we have found about children's ideas on floating and sinking</u>

Children quite often think that whether or not an object floats depends on:

1. the material it is made of (e.g. plastic would probably float but metal mostly sinks);
   [We would want to explore and enrich this idea.]
2. if it has air in it, or not;
3. its weight (e.g. heavy things float lower in the water or sink);
4. it having holes (e.g. holes may trap air and keep it afloat, or holes may let water water in and make it sink);
5. its shape (e.g. if it is hollow or has 'edges' then it will float);
   [We would want to qualify or modify these views.]
6. depth of water (e.g. objects will float lower in deeper water);
7. length of object (e.g. a longer object may sink);
8. it having a motor (e.g. that's why big metal ships float);
9. who or what made it (e.g. man-made products can float but most nature-made things sink apart from wood).
   [We would want to challenge these ideas.]

What children want to know about floating and sinking

We have found that children aged 9-12 years most often ask questions about:

1. Materials (e.g. Why do most metals sink?)
2. Objects (e.g. How do boats stay up in the water?)
3. People (e.g. When I'm on my back in the pool I'm kind of relaxed and I float but when I twist or turn or lower my legs a bit I go under. Why is that?)
4. Other animals (e.g. How come insects float?)
5. Weight or size (e.g. Why do big ships float and why do little things like paper clips sink?)
6. A general rule (e.g. Why do some things float and some things sink?)

The most useful idea for primary children to develop

The most useful concept for children to develop at the primary level is that an object will float if it is light for its size. Certainly depth of water, length of object, having a motor or who made it are not relevant. Some objects like a candle float but do not have air in them. Only if an object is heavy for its size will it sink. Holes do not make a material that floats sink (try putting holes in a candle and see if it sinks).

Special Note:

In the investigations and projects which follow the scientists' view is given for your benefit only. Words such as 'density' and 'proportionately' are not ones to use with primary children. Let them express their conclusions in their own words.

SUGGESTED INVESTIGATIONS

The investigations proposed in this section are designed to allow children to

(i) test some of their ideas and thereby begin to gain some understanding of floating,

(ii) develop various skills of processing information (e.g. predicting, observing, reasoning),

(iii) acquire some scientific facts (e.g. which materials float and which do not).

INVESTIGATION 1: WHICH MATERIALS FLOAT?

This is an investigation of the floating of objects which are made entirely of one material without air spaces or without being shaped to float, e.g. a solid block of material.

Commonly-held children's views

We have found that children can be strongly influenced by:

(a) the size of an object (big things will sink despite the material);

(b) whether or not it is thought to have air inside it (some children say a candle floats because it has air inside it);

(c) the shape of the block (e.g. if a block is reshaped so it is flat with a large surface then it will float according to some children).

Scientists' view

An object made of a single material will sink if it is heavier than an equal volume of water. (In children's terms, it will sink if it is heavy for its size.)

Investigation [Class, mini-group (2-3 children) or individual]

A range of materials can be investigated to find out whether or not they float - (e.g. wood, candle, rubber, polystyrene, aluminium, glass, plastic, pumice, steel clip).

Recording

(a) Minigroup or individual

Material	We expect it will (float/sink)	Why we think that	We find it (floats/sinks)

(b) Class (summary)

Materials	Why we think they floated or sank	What most scientists think
A. Floated		They are light for their size.
B. Sank		They are heavy for their size.

To be added, possibly at the end of this investigation

INVESTIGATION 2: DO HOLES IN FLOATING MATERIALS AFFECT THEIR FLOATING?

Commonly-held children's views

Holes will let the water through and the material will sink.

Scientists' view

If a material floats then holes in it will not cause it to sink.

Investigation [Class or mini-group]

Float various materials which float (e.g. disc of candle, piece of polystyrene, cork, apple) in water, predict the effect of making holes in them, and then test.

Recording [Class, mini-group or individual]

Material that floats	We expect that with holes in it it will (sink/float)	We find it (floats/sinks)

Conclusion (in own words)

SPECIAL NOTE

A scientific idea is one that is capable of being tested. If it can't be refuted or rejected by testing then it will survive - at least until such time as it is refuted or alternatively is replaced by an even more useful explanation. This investigation, and the next two, are designed to enable children to challenge and refute ideas which they may hold. We are aware that it is a quite different approach to that normally used in schools (where children usually find out that something is the case, rather than that it is not the case), but are hopeful that you will be able to help children in the manner suggested.

INVESTIGATION 3: DOES DEPTH OF WATER AFFECT FLOATING?

Commonly-held children's views

The deeper the water, the lower/higher the object will float. In really deep water it may even sink, according to some children (possibly associated with swimming out of one's depth).

Scientists' view

Depth of waterdoes not affect the level at which an object floats.

Other possible responses

Some children may see what they think they are going to see. If they already believe that an object will float lower in deeper water, they may think they see it lower. Hence the need to mark the flotation level on the object, and to record observations.

Investigation [class or mini-group]

(a) Have containers with various depthsof water. Teacher (or child) floats objects such as a block of wood, toy boat, partly filled bottle or jar in one container and then predict how it will float in the others.

(b) Children mark flotation level on an object floating in shallow water and predict whether or not the level will change when it is put in a greater depth of water.

Recording [class, mini-group or individual]

Object	We expected it would float (lower/same/higher)	We find it floated (lower/same/higher)
Woodblock Bottle Boat		

Conclusion (in own words)

INVESTIGATION 4: DOES LENGTH OF AN OBJECT AFFECT ITS FLOATING?

Commonly-held children's views

A long piece of candle will float lower than a short piece (because it is heavier). A long piece of wood will float lower than a shorter piece of the same kind. If you cut the top (visible) part off an iceberg the rest would sink because the floating part has gone.

Scientists' view

The proportion of the object below the water's surface depends on the nature of the material, not how much of it there is. A long plank will float at the same level as a short plank of the same wood because the density is the same in both cases.

Different volumes of material will float proportionately as high in the water. (If a small volume floats at half its thickness, a large volume will also float at half its thickness.)

Investigation [class or mini-group]

Float a series of short objects (e.g. piece of candle, piece of wood, plastic block) on water. Show children longer pieces of the same materials, have them predict and then check these flotation levels.

Recording

As for investigation 3.

Conclusion (in own words)

Extension activities

Cut 2 pieces of different area from the same thickness of polystyrene. Children predict and then check the flotation level.

Cut 3 pieces of the same area from the same thickness of polystyrene. Join 2 pieces, one on top of the other, with a small piece of cellotape. Children predict how low each piece will sink in the water.

EXPERIMENTAL PROJECTS

The main emphases with the experimental projects are on the children

(i) recognising that ideas in science must be testable,

(ii) having an opportunity to test some of their ideas about how non-floating materials may be made to float,

(iii) acquiring some scientific facts (e.g. which material is the best floater).

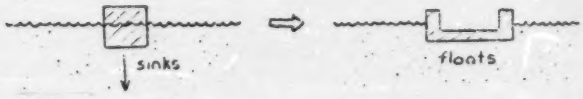
PROJECT 1: HOW CAN WE MAKE NON-FLOATING MATERIALS FLOAT?

Commonly-held children's views

Some children have suggested that a small ball of plasticine may be made to float if it is shaped into a thin, flat sheet, or into a long thin 'sausage'. We have also found that after children have seen a cube of plasticine sink, most have predicted that a hollowed-out, equivalent-sized cube of plasticine would sink too. They have been quite surprised to find that it floated (provided it was lowered gently into the water).

Scientists' view

We can make non-floating materials float by increasing their effective size without increasing their weight, or by decreasing their weight without decreasing their effective size (e.g. by hollowing them out).



small effective size — reshaped to have a larger effective size

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Some simple experiments

Children can experiment with non-floating materials (such as lumps of plasticine, a potato, carrot, thin sheet of copper or aluminium) to see if they can get them to float. One form of recording would be a chart showing pictures of the material/object in water before and when floating, accompanied by a short text explaining what was done to make it float. At the conclusion there could be a teacher-guided class discussion focussing on the chart to consider whether or not there was any common means by which the non-floaters were made to float.

Extension activity (shaping a non-floater to carry the greatest possible load)

If a number of children are each given an equivalent amount of plasticine they can experiment to see who can construct a floater to carry the greatest load. A fair test might involve the greatest number of marbles the floater could carry without sinking.

Drawing conclusions

Children should be encouraged to formulate in their own words the idea that for a given weight of material the greater the amount of water it can be made to displace (push aside) the greater will be the floating capacity of the object. Objects which are light for their effective size are the ones that float.

PROJECT 2: HOW CAN WE RAISE A SUNKEN OBJECT TO THE SURFACE?

Sometimes people want to raise sunken objects to the surface. Dredges raise materials such as oysters, shingle and gold, but we are concerned here with objects which have inadvertently sunk, such as boats (which once floated) and cars (which never floated).

The children may be able to suggest, and experiment with, various means of raising model sunken objects. For example, a bottle filled with water could represent a sunken submarine. This could be raised by inserting two pieces of plastic tubing or plastic straws in the 'cork'.

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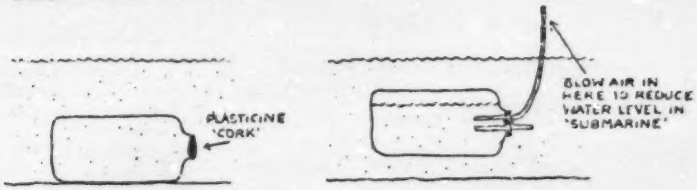
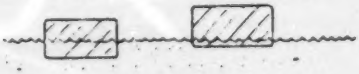


PROJECT 3: WHICH MATERIAL IS THE BEST FLOATER?

If a boat is swamped then it is likely to sink. Which buoyant material should boat-builders place in the limited spaces on a boat if they wanted to prevent it sinking? Which material (e.g. balsa, willow, plastic, polystyrene) floats best and would give the most support? Children will probably need considerable help if they are to devise a fair test. The first requirement would be blocks of material of equivalent size. Two possible ways of measuring floatability would be:

(a) the greater the amount of material above water, the greater the floatability;



(b) the greater the force required to push the material under the water line, the greater the floatability.

Possible extension activities

(a) Siting buoyancy material for stability

If it is found that polystyrene is the best floater then the children could try attaching pieces of the material to a plasticine 'canoe'. They could experiment with both amount and siting of the polystyrene to determine how much is required and where is the best place to attach it so the canoe remains floating and stable when filled with water.

(b) Testing life-jackets for buoyancy

During the summer months it may be possible to test in the school pool which life jackets are the best floaters. Perhaps the best way would be to attach equivalent weights until a life-jacket just sank.

PROJECT 4: HOW MUCH WATER DOES AN OBJECT PUSH OUT OF ITS WAY WHEN IT IS FLOATING COMPARED WITH WHEN IT IS SUNKEN?

NOTE: We feel that the following project is probably suitable only for fairly able 10-12 year olds.

Many children find it strange that when non-floating material (such as plasticine) is shaped into a floating object (such as a hollow box or 'canoe') it actually pushes out more water than when it is completely submerged. A reasonably simple way to investigate this is to fill a jar to the brim each time and catch the amount of water that is pushed out when the object is submerged and when it is floating. After they have seen the amount of water pushed out by the object when it is completely submerged, the children might like to predict whether the object when it is floating will push out more, less or the same amount of water. They check this.

If the water pushed out by the object when it is floating is collected in a small light container then children can compare the weight of the water with that of the object that pushed it

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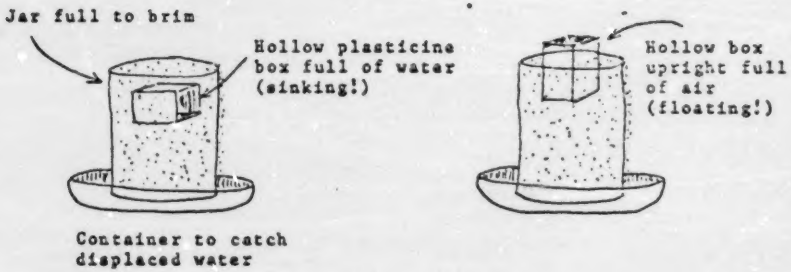
out. A rough but adequate measure for this situation is to hold the object in one hand and the collected water in the other. This avoids the problem of scales that don't measure too accurately or other factors than can affect the amount of water pushed out. Children are sometimes surprised to find that they weigh about the same. (The weight of water pushed out by <u>any</u> floating object is the same as the weight of the object.)

OBSERVE ⟶ PREDICT ⟶ OBSERVE


Jar full to brim
Hollow plasticine box full of water (sinking!)
Hollow box upright full of air (floating!)
Container to catch displaced water

SCIENCE AND SOCIETY

Non-experimental projects

Through studying the application of floating and sinking to our lives (past and present) children can

(a) gain some knowledge of social value, and

(b) recognise that science can help them make better sense of their world.

Three optional projects are proposed, to provide children with a choice. Their research is likely to take the form of consulting books and people. The teacher will probably need to offer guidance in setting out their main ideas and exemplifying them. Whether the children work individually or in mini-groups, and whether the results of their research are displayed in chart, booklet or other format is left to the teacher and/or the children to decide.

Project 1: What use are floaters?

Things that children might investigate in this project include:

(a) transport (e.g. shipping, floating logs to mills)

(b) recreation (e.g. duck decoys, boats, surfboards)

(c) support (e.g. floating dock, emergency floaters, life jackets)

(d) marking underwater objects (e.g. buoys)

(e) indication of horizontal (e.g. spirit level, aeroplane meter)

(f) separation (e.g. fat from water)

(g) regeneration (e.g. coconut floating to another island, mangrove seeds)

Project 2: Can floaters be problems?

Aspects that could be investigated here include:

(a) pollution (e.g. oil)

(b) boating hazards (e.g. icebergs, logs and lost containers)

(c) mixtures that separate with one substance floating on top of the other and requiring to be shaken, stirred or remixed before use (e.g. paint, aerosol sprays, some medicines, lotions, peanut butter)

Project 3: What use are sinkers

This study could investigate such things as:

(a) mixtures, as above

(b) anchors (e.g. for boats and buoys, sinkers for fishing lines)

(c) for testing eggs (good eggs sink, bad eggs float)

ACKNOWLEDGEMENTS

We are most grateful to David Symington, Ken Appleton and Eleanor Hawe for commenting on an earlier draft of this booklet.